



Atmospheric Pressure and Wind

Chapter 5

The Nature of Atmospheric Pressure



- Atmospheric Pressure is the force exerted by the gas molecules on some area of the Earth's surface or on any body.
- This pressure is exerted on every solid or liquid surface it touches
- It is omnidirectional, exerted equally in all directions.

Factors Influencing Atmospheric Pressure



- Density and Pressure
 - Density is the mass of matter in a unit volume
 - The density of a gas is proportional to the pressure on it and the pressure the gas exerts is proportional its density. The denser the gas, the greater the pressure it exerts.
 - Atmosphere is held to the Earth by gravity. So as the air moves away from the Earth, there is less gravity and less density, thus less pressure.
 - Higher altitude, less density, less pressure
 - Lower altitude, higher density, higher pressure

Factors Influencing Atmospheric Pressure

- Temperature and Pressure
 - If volume is held constant
 - An increase in temperature produces an increase in pressure,
 - A decrease in temperature produces a decrease in pressure.
 - **Imagine a balloon, if it's hot, it will burst, if it's cold it deflates.**
 - One factor to change this (important)
 - As air rises, the molecules will spread out, so pressure does decline as does the temperature.
 - As air is compressed or altitude is lowered the molecules are compressed and the pressure is increased and the temperature increases



Dynamic Influences on Air Pressure

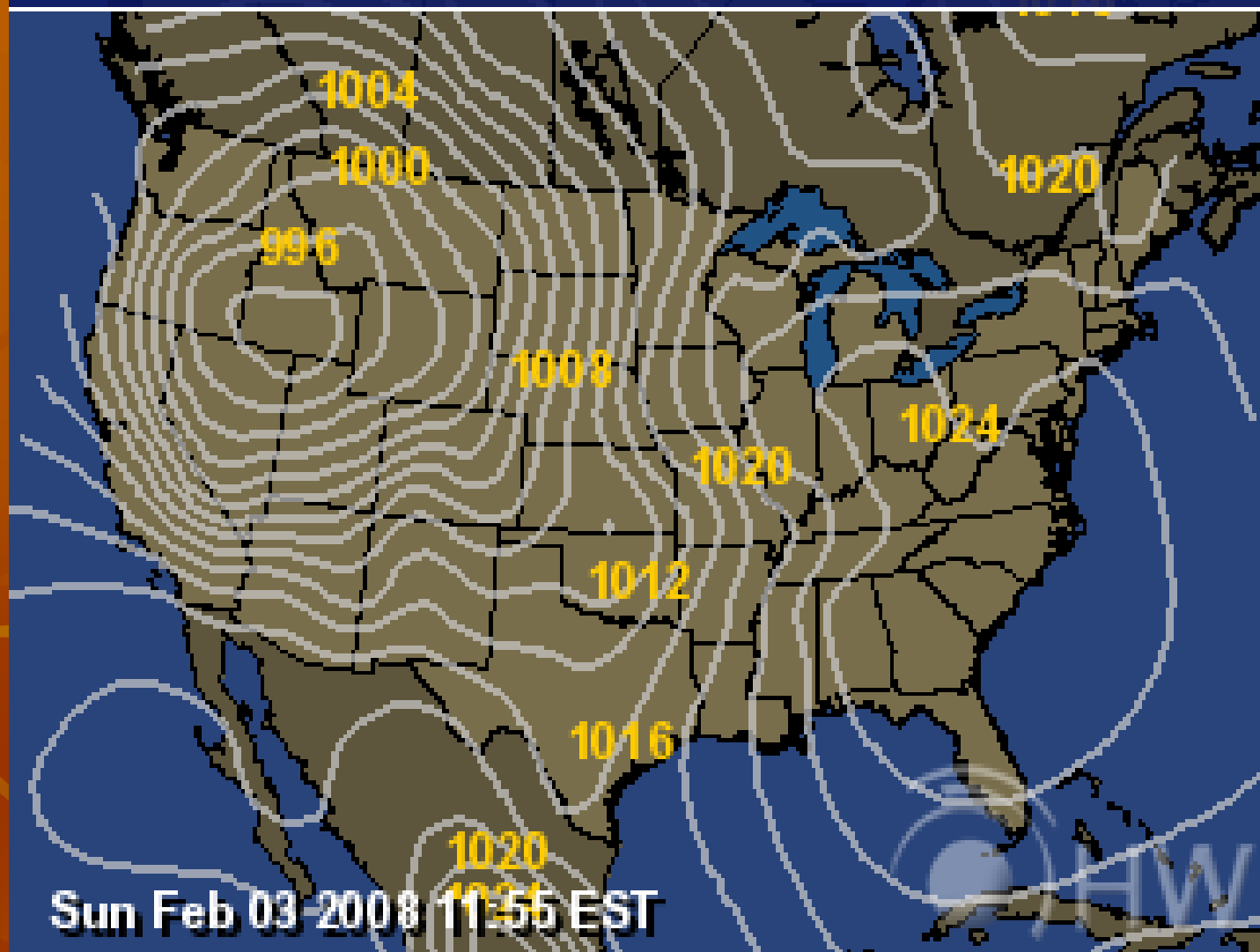
- Atmospheric pressure is affected by:
 - Differences in air density
 - Air temperature
 - Air movement
- High and Low Pressures
 - Strongly descending air /with high pressure at the surface – **Dynamic high**
 - Very cold surface conditions /with high pressure – **Thermal High**
 - Strongly rising air associated with low pressure at the surface – **Dynamic low**
 - Very warm surface conditions /with low pressure – **Thermal low**





Current Pressure

HAMweather.com



Mapping Pressures with Isobars

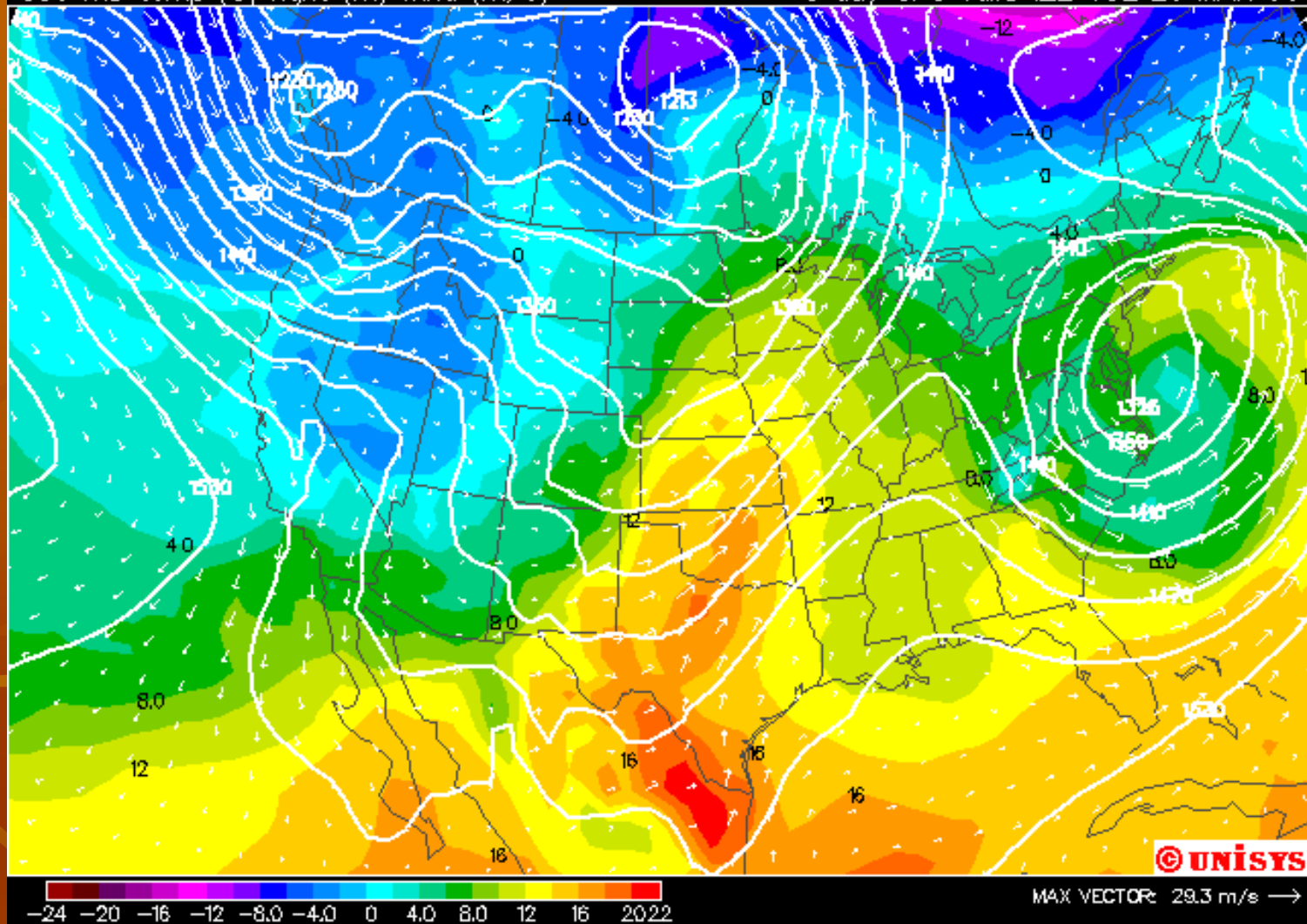


- Atmospheric pressure mapped with isobars
- Measured with Barometers
- Measurements
 - Millibars
 - Highs and Lows
 - Ridges and troughs
 - Pressure gradient



850 mb temp (C) hght (m) wind (m/s)

3 day GFS valid 12Z TUE 29 MAR 05

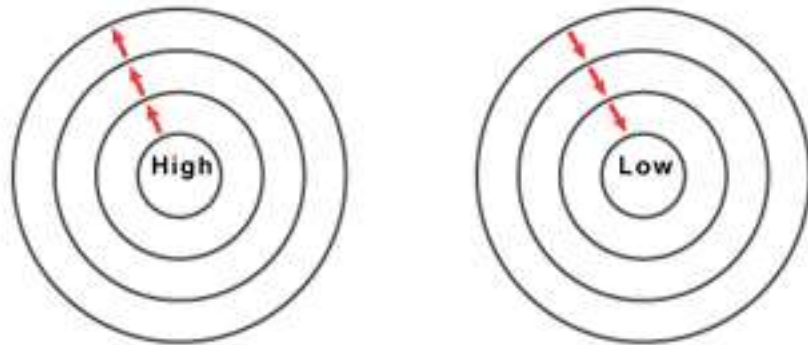


The Nature of the Wind

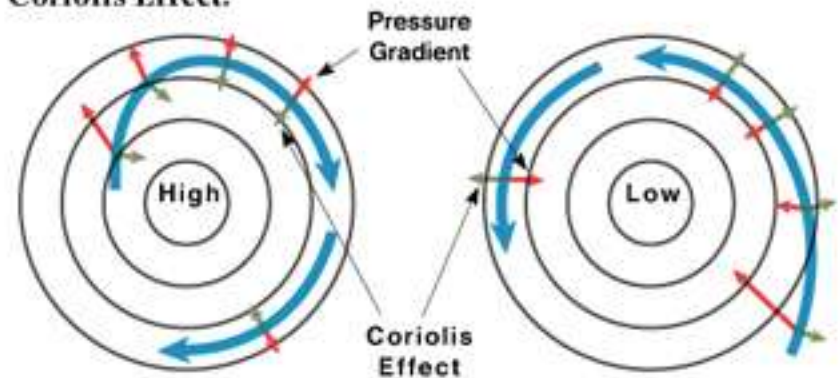
- Direction of Movement
 - Pressure Gradient
 - Pressure-gradient force acts at right angles to the isobars in the direction of the lower pressure
 - The Coriolis Effect
 - The Coriolis Effect deflection acts at 90 from the direction of movement, right in the north, left in the south.
 - Friction
 - In lowest portions of the troposphere friction slows the wind movement, thus influencing the Coriolis effect by reducing it.
 - Friction Layer extends only about 1000 meters above the ground.



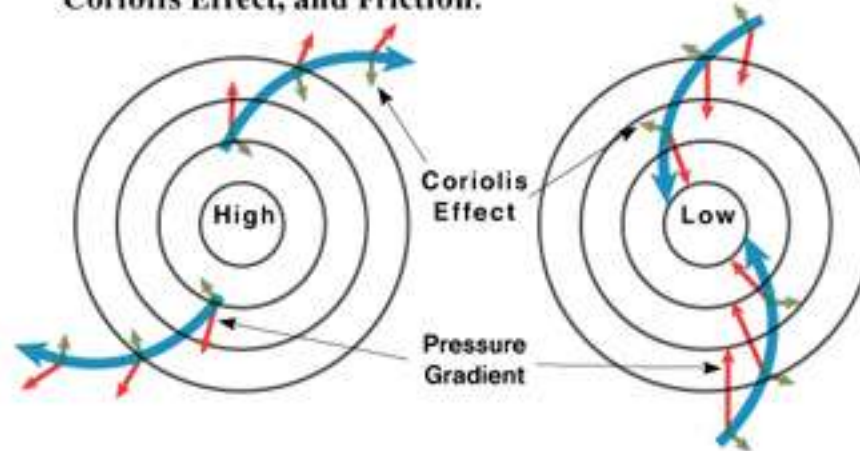
(a) Pressure Gradient Force only:



(b) Upper Atmosphere---Pressure Gradient Force and Coriolis Effect:



(c) Lower Atmosphere---Pressure Gradient Force, Coriolis Effect, and Friction:



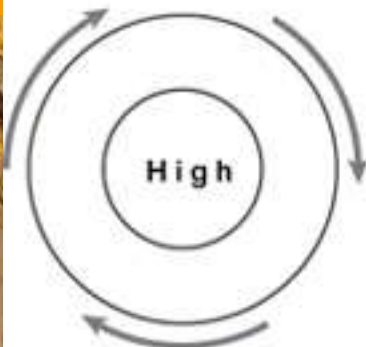
Cyclones and Anticyclones



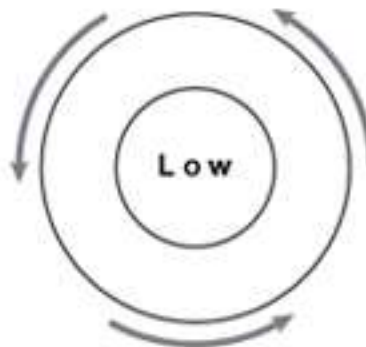
- Distinct and predictable wind-flow patterns develop around all high and low pressures centers
 - Northern hemisphere
 - Low pressures – counter clockwise
 - High pressures – clockwise
 - Southern hemisphere
 - Low pressures – clockwise
 - High pressures – counter clockwise
- Wind Speed
 - If the gradient is steep, the wind speed is fast
 - If the gradient is gentle the wind speed is slow



Northern Hemisphere upper-air pattern

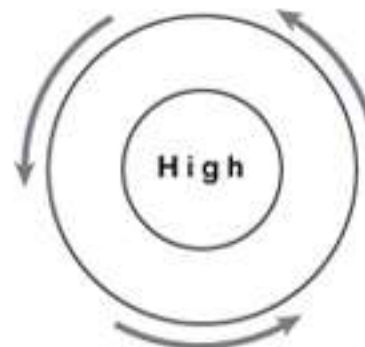


Anticyclonic geostrophic
clockwise flow

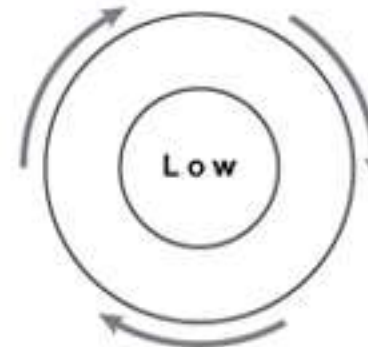


Cyclonic geostrophic
counterclockwise flow

Southern Hemisphere upper-air pattern

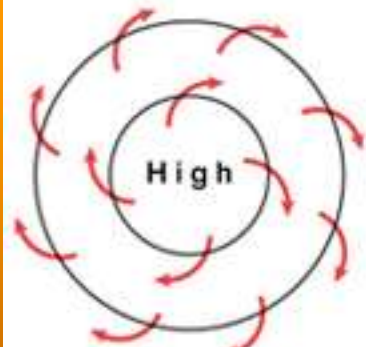


Anticyclonic geostrophic
counterclockwise flow

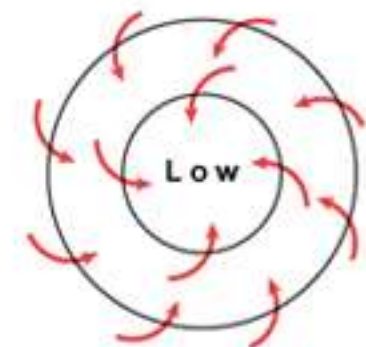


Cyclonic geostrophic
clockwise flow

Northern Hemisphere friction-layer pattern

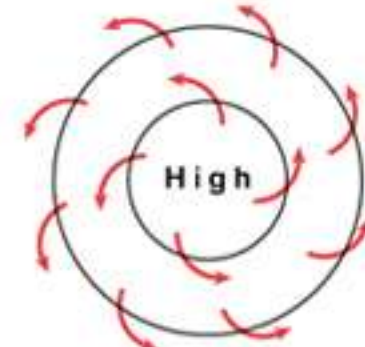


Anticyclonic divergent
clockwise flow

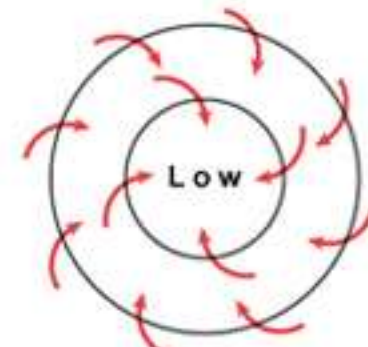


Cyclonic convergent
counterclockwise flow

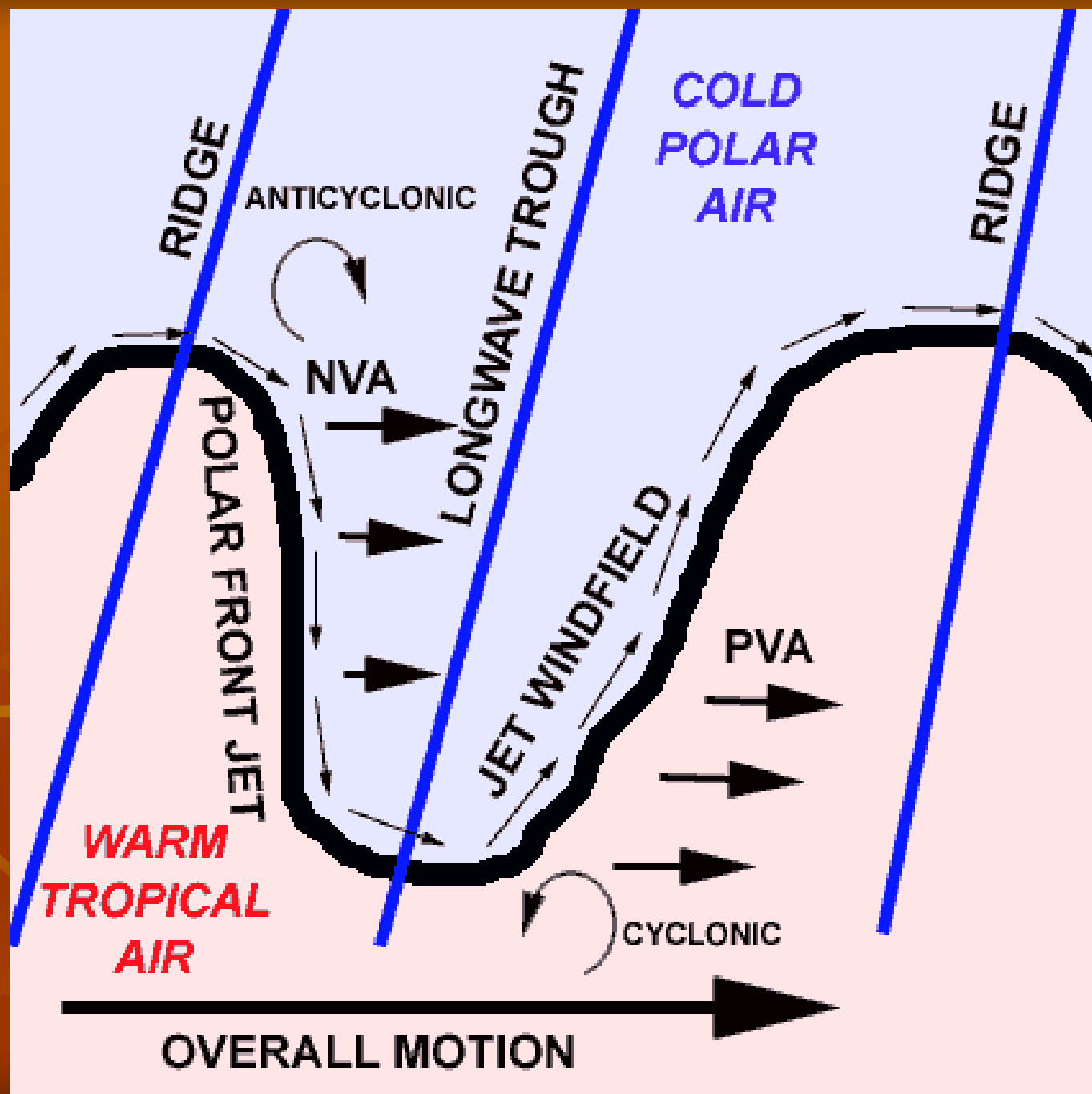
Southern Hemisphere friction-layer pattern



Anticyclonic divergent
counterclockwise flow



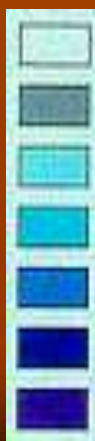
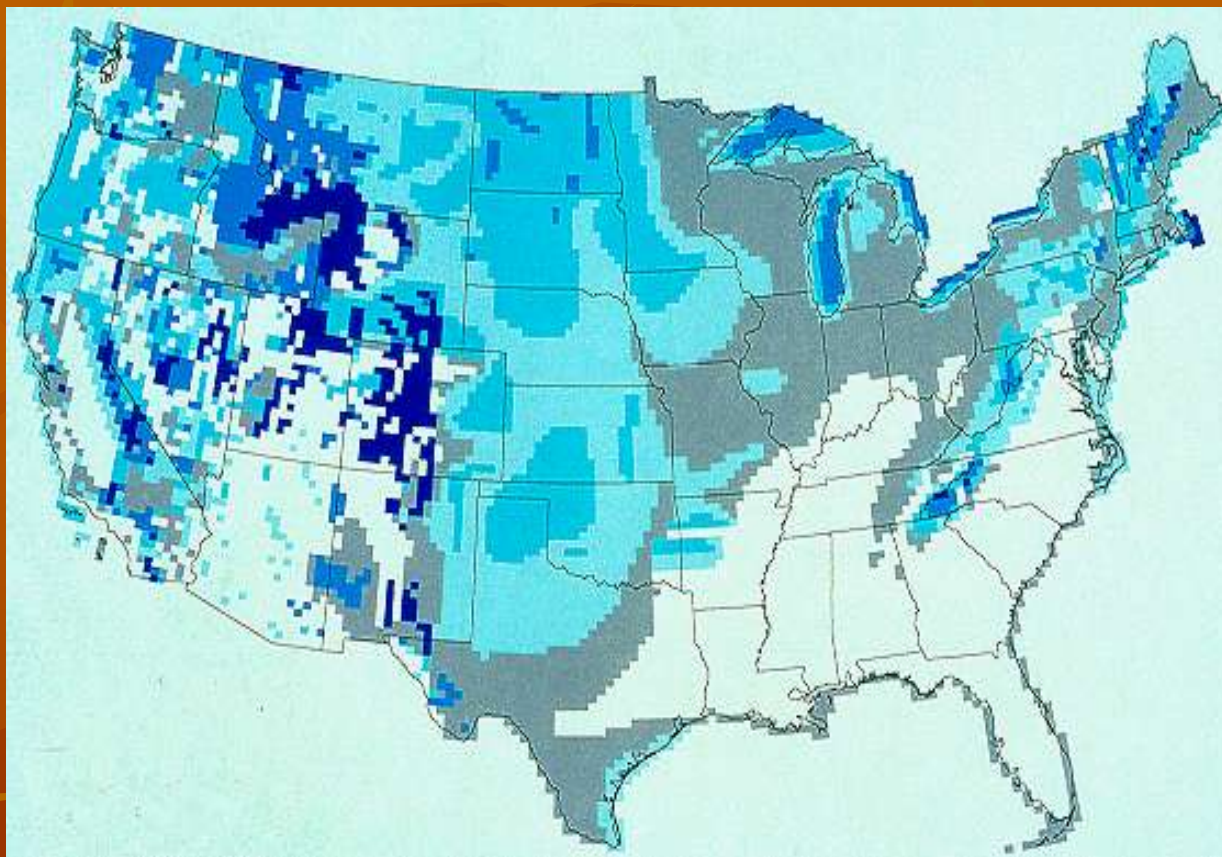
Cyclonic convergent
clockwise flow



General Circulation of the Atmosphere

- Earth's atmosphere is a dynamic medium
 - The circulation of the atmosphere is the principal mechanism for both longitudinal and latitudinal heat transfer and global patterns of insolation as a determinant of world climates
 - Cells of circulation only exist in the low latitudes, called Hadley cells.



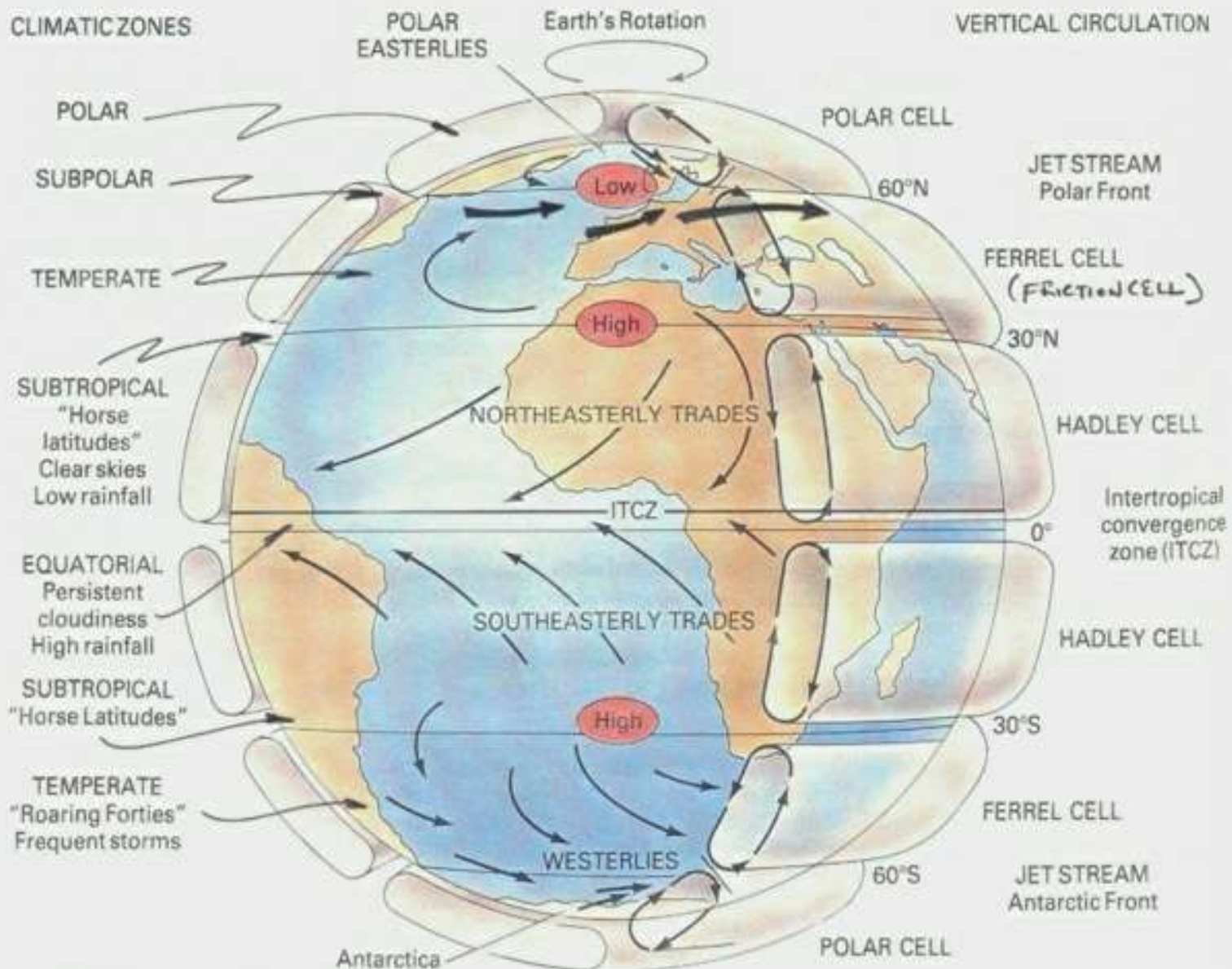


1	<200	<5.6
2	200-300	5.6-6.4
3	300-400	6.4-7.0
4	400-500	7.0-7.5
5	500-600	7.5-8.0
6	600-800	8.0-8.8
7	>800	>8.8

General Circulation of the Atmosphere

- There are seven atmospheric components ranging from the equator to the pole, both north and south
 - Polar High
 - Polar Easterlies
 - Polar Front (subpolar low)
 - Westerlies
 - Subtropical high
 - Trade winds
 - Intertropical convergence zone





Circulation of the Atmosphere

- Subtropical Highs (STH) Horse Latitudes

- 30 degrees latitudes, large high pressure area over the oceans, clear, warm, calm weather

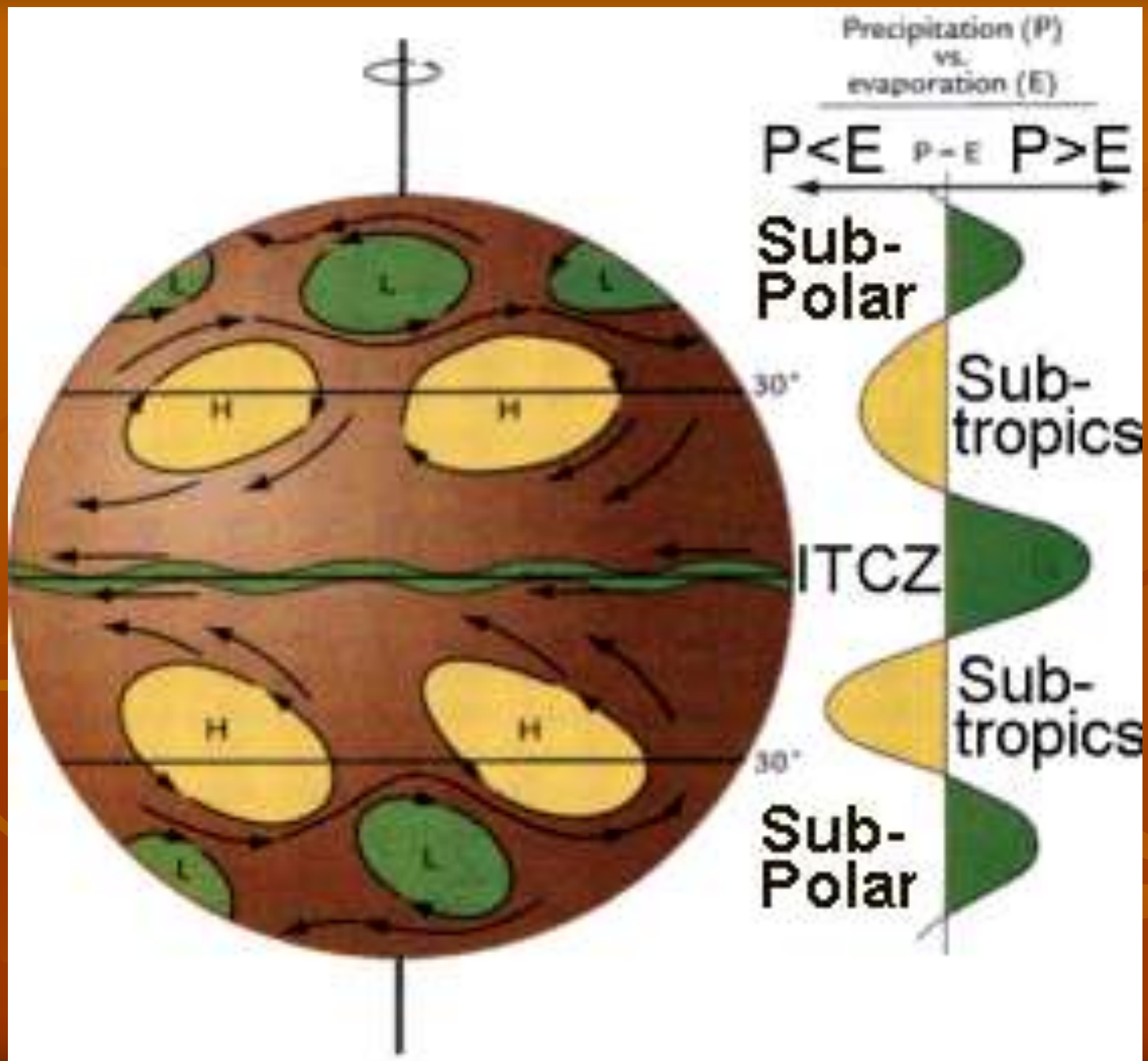
- Trade Winds

- Issuing from the equator toward sides of the STHs, and toward the west, used by sailors to quickly move sailing trading ships.

- Intertropical Convergence Zone (ITCZ)

- Where the northeast and southeast trade winds come together in the vicinity of the equator. Calm winds, doldrums, narrow cloud bands.





Circulation of the Atmosphere

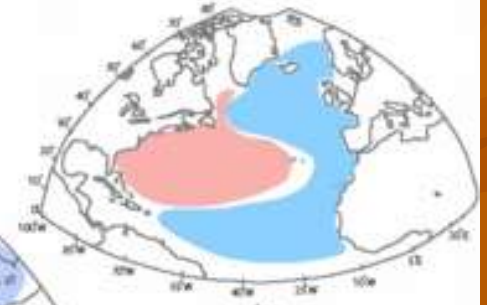
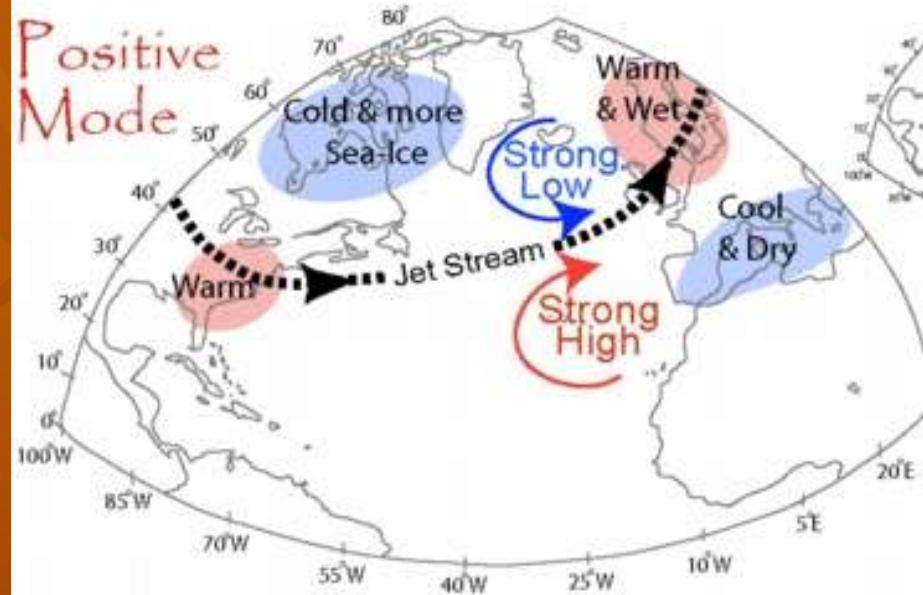
■ Westerlies (Midlatitudes Winds)

- Flow west to east in the mid latitudes, 30 to 60 degrees, cover much of the earth
- Surface Westerlies not strong, but in upper atmosphere, found in the Jet Streams
 - Polar Front Jet Stream,
 - Subtropical Jet Stream
- Rossby Waves, waves in the jet streams towards the poles and the equator
 - Zonal and meridional flows



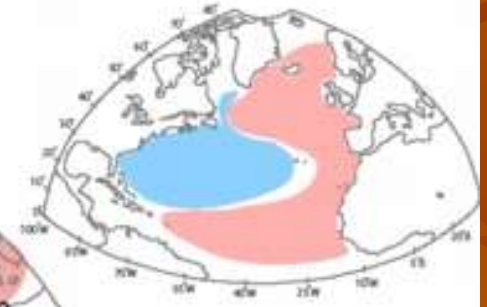
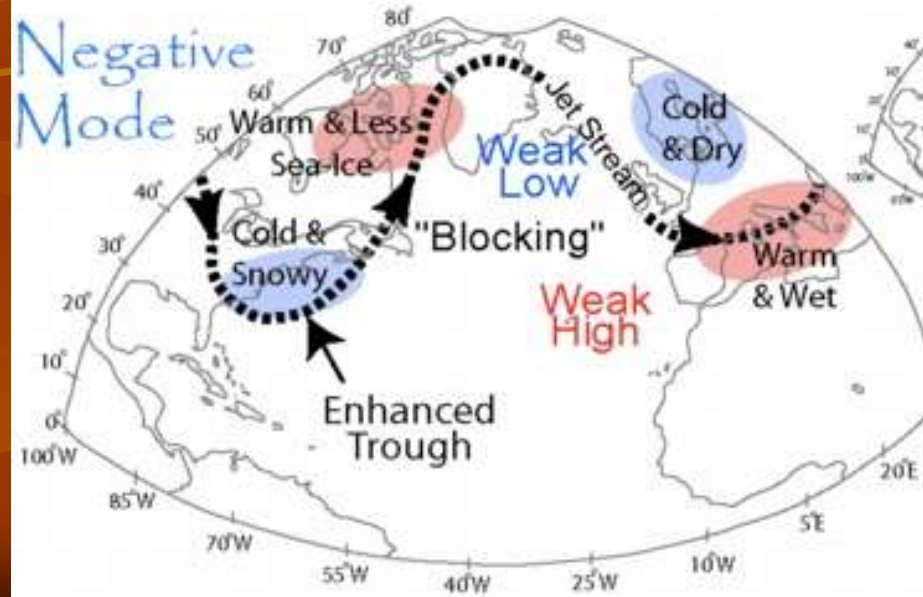
North Atlantic Oscillation

Positive
Mode



Associated
SST Patterns
(~12-14 yr period)

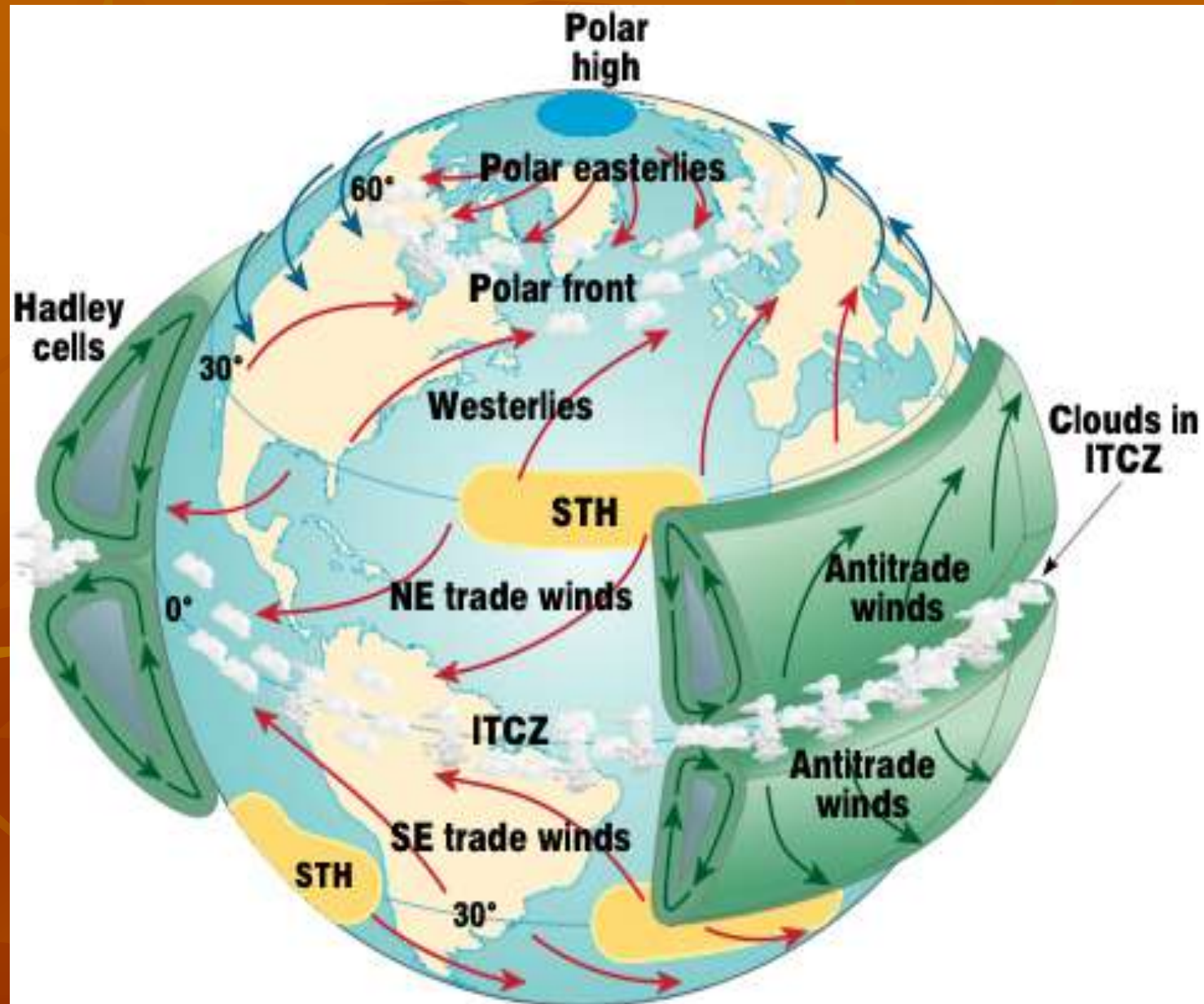
Negative
Mode



Circulation of the Atmosphere

- Polar highs— high pressures cell over Antarctic, strong and persistent. Arctic high is less predominant
- Polar easterlies— wind system at 60° latitude, moves east to west.
- Polar front— frontal zone in front of semi permanent lows (Subpolar low pressures) at 50 to 60° latitude, melting ground between the cold winds of the polar easterlies and the warm winds of the Westerlies



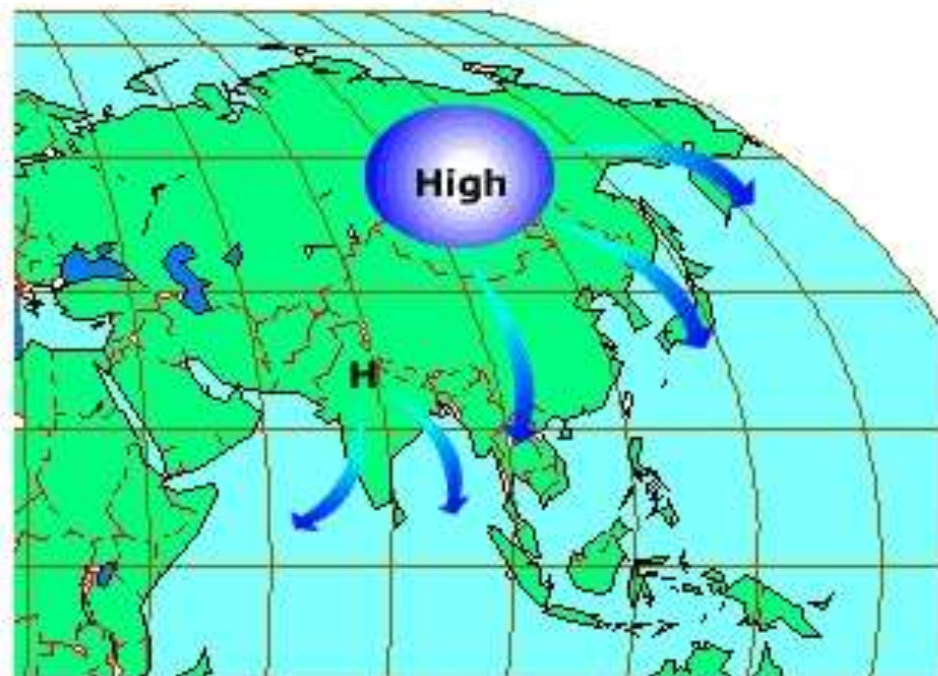
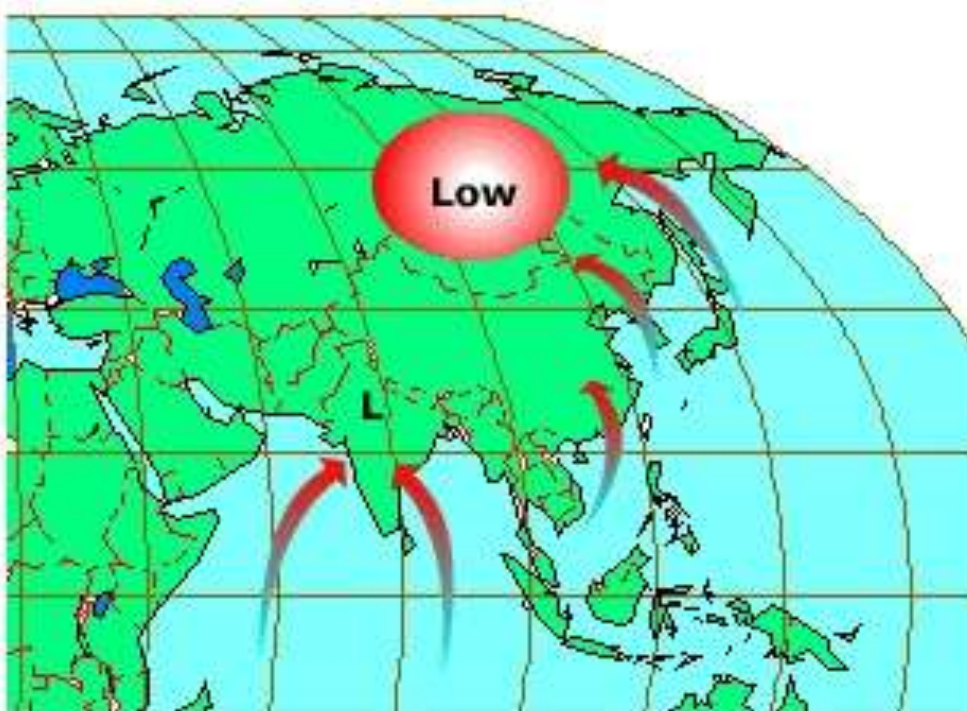


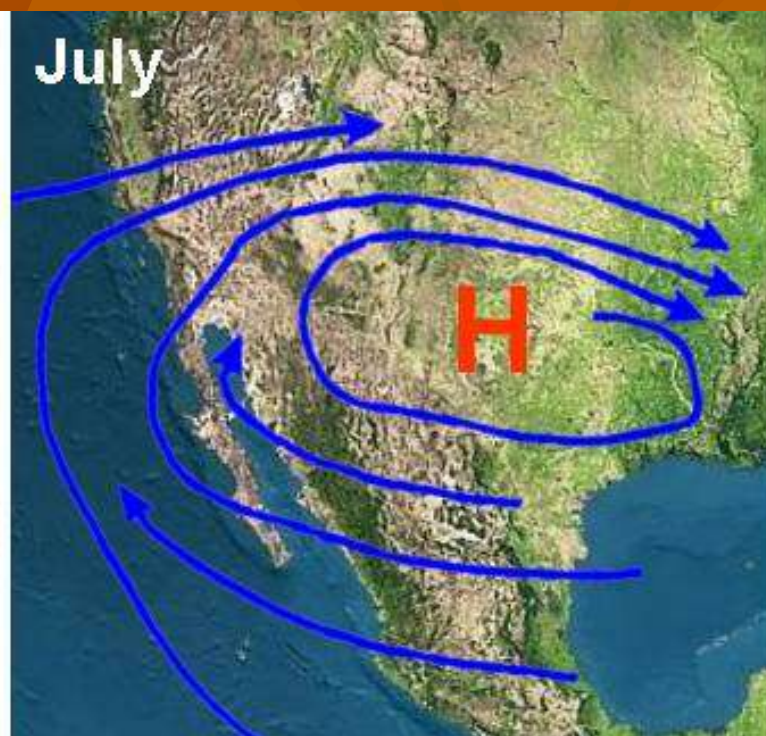
Modifications of the General Circulation

■ Monsoons

- Disturbances in the general pattern of the circulation of the atmosphere
 - On-shore flow of winds in the summer, off shore flow in the winter
 - Seasonal precipitation; heavy in the summer; dry in the winter.
 - Found largely in the South, and Southeastern Asia and Central Africa. (India, Southeastern Asia, and Japan)
 - Economic and life preserving in these areas





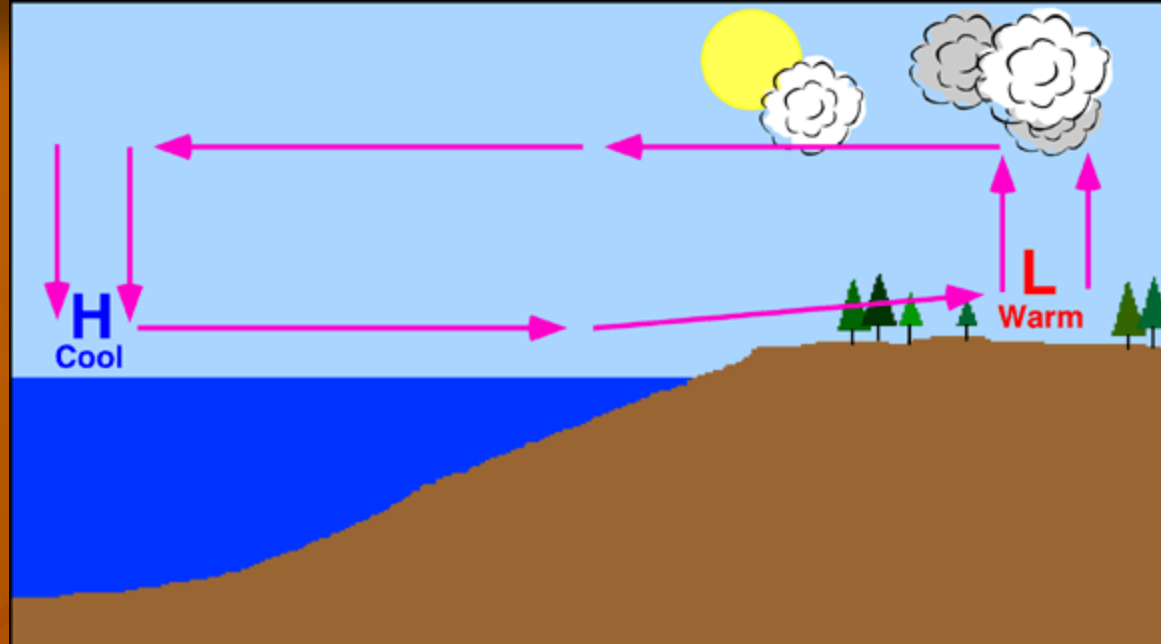


Mean 50 kPa Flow Patterns over SW North America

Modification of the General Circulation

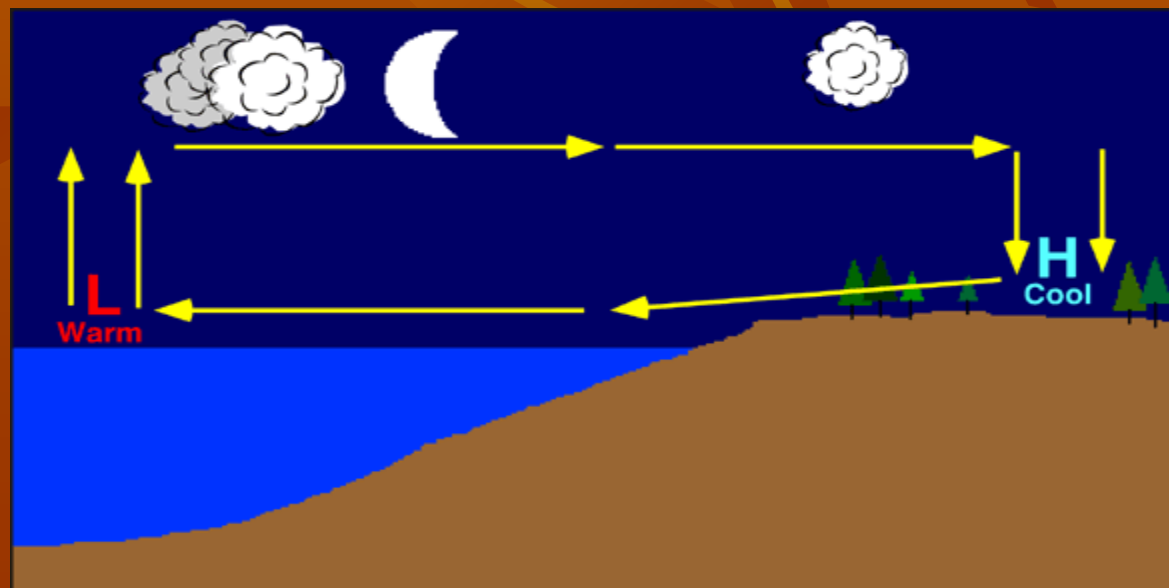
- Localized Wind Systems
 - Sea and Land Breezes
 - Wind moving from Sea to land and back
 - Valley and Mountain Breezes
 - Wind moving from mountains to valleys and back
 - Katabatic Winds
 - Originate in cold upland area and cascade towards lower elevations
 - Foehn/Chinook Winds
 - Originates only with a steep pressure gradient developing on the windward side of mountains
 - Santa Ana Winds
 - Develop from high pressures over Rockies and rush down to California

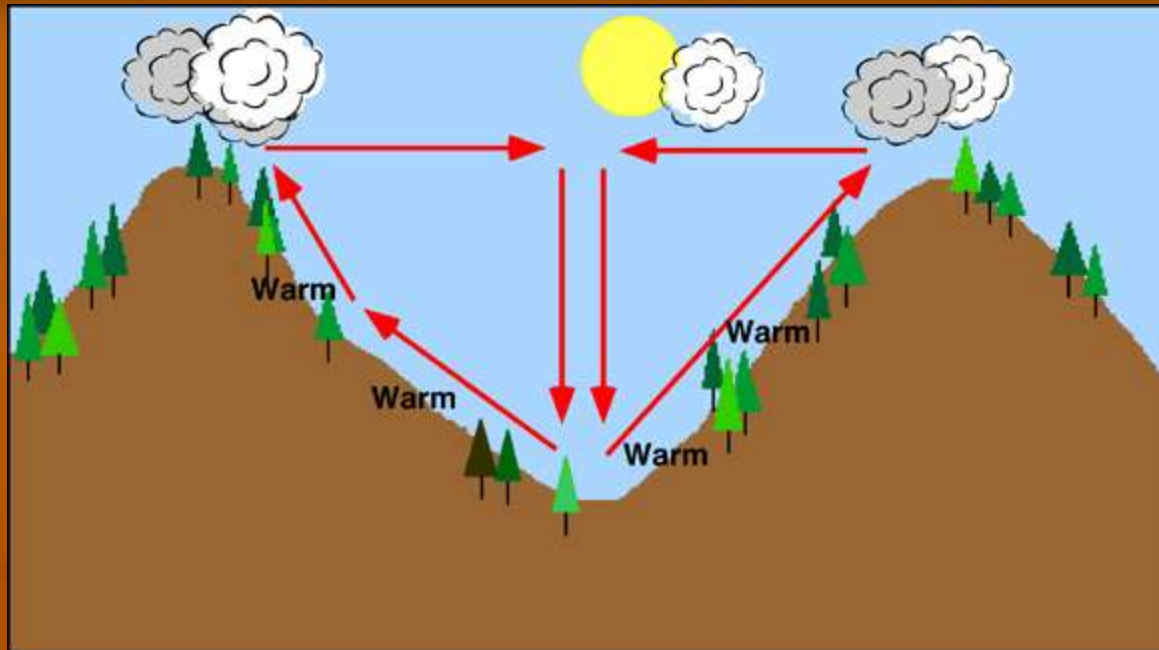




Day
Sea
Breeze

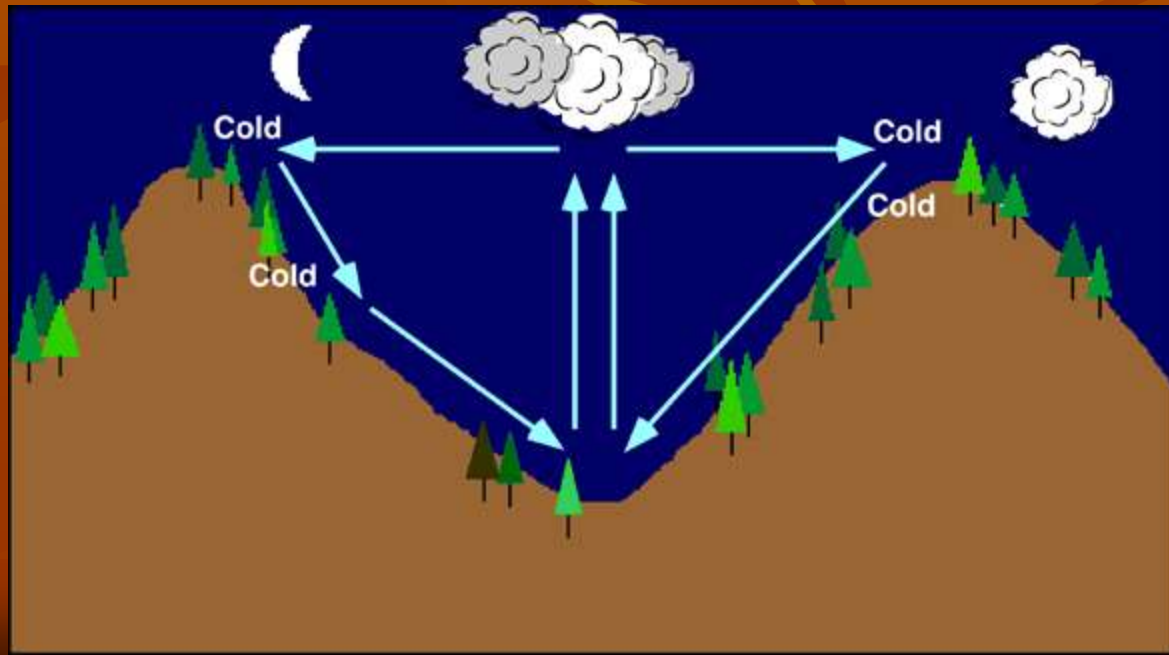
Night
Land
Breeze



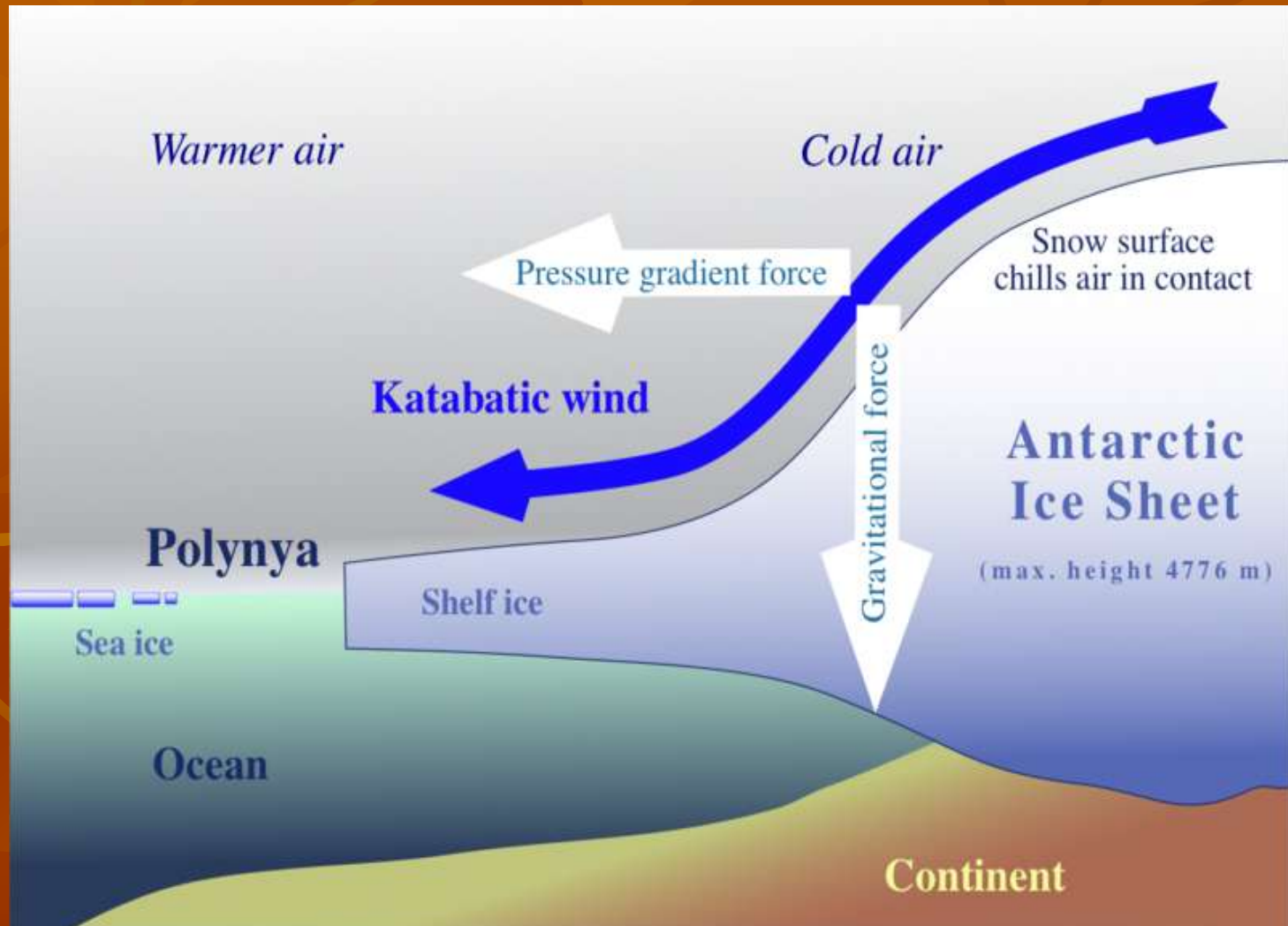


Daytime
Mountain
Breezes

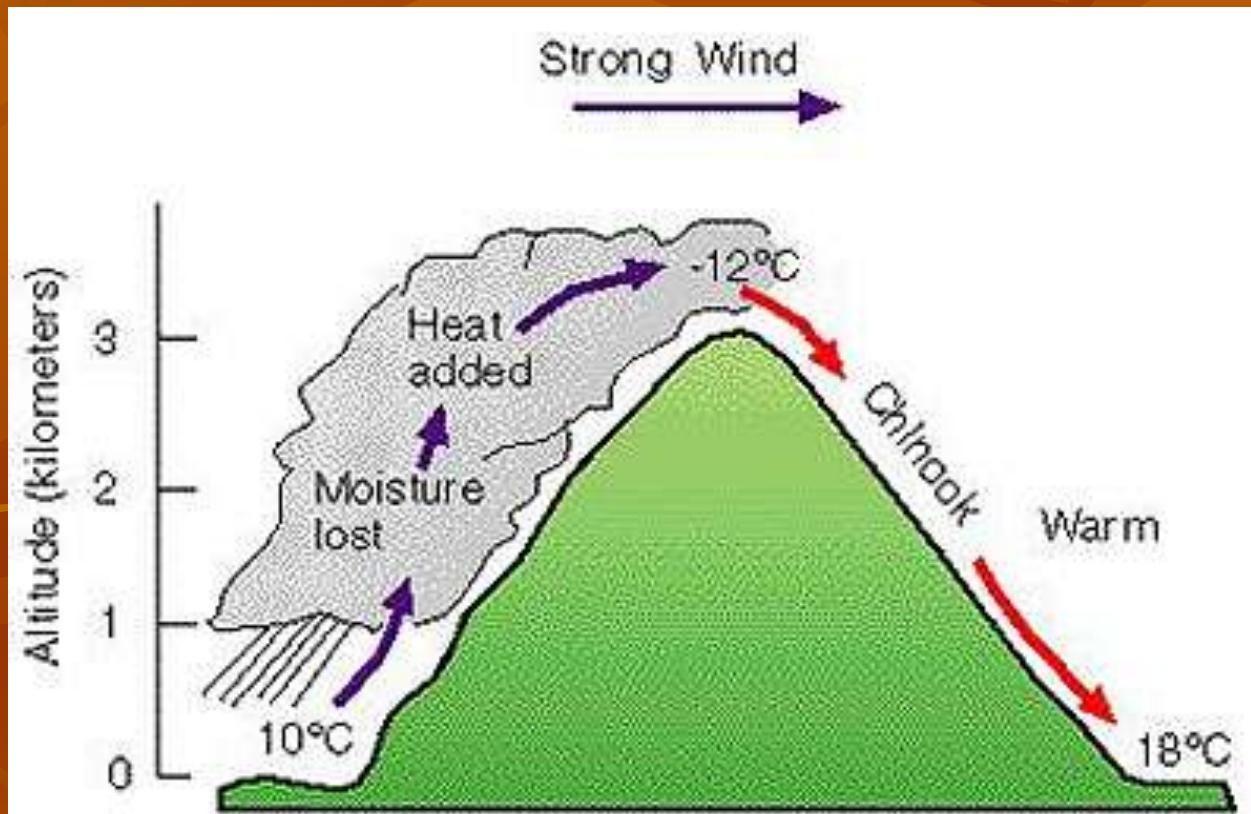
Night
Mountain
Breeze



Katabatic Winds



Chinook Winds



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Santa Ana Winds

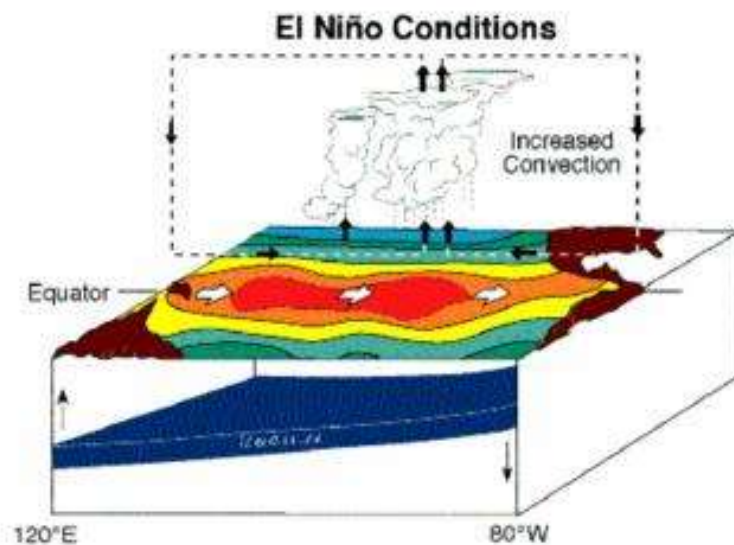
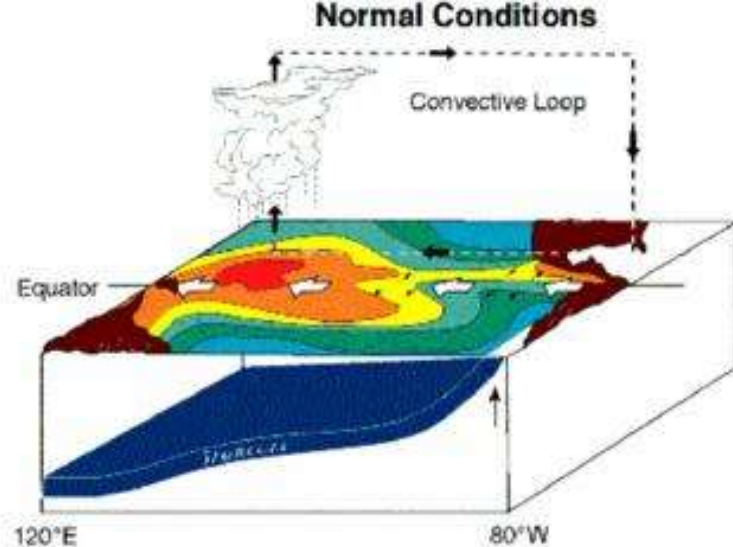


El Nino- Southern Oscillation



- An episodic atmospheric and oceanic phenomenon in the Pacific Ocean
 - Abnormally warm water appears at the surface of the ocean off the west coast of South America
 - Can Causes increased rains in northern hemisphere, less fish off the coast of South America, and drought in Southeast Asia
 - Causes not totally understood





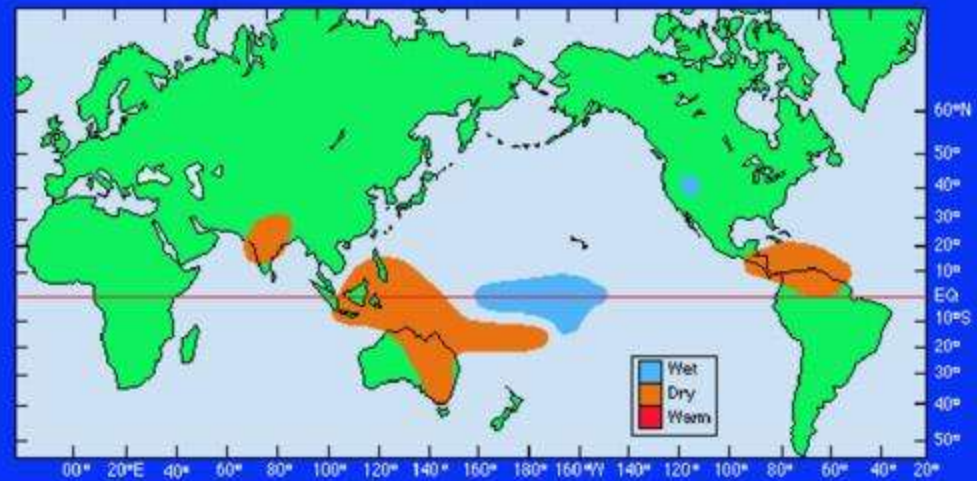
NOAA/PMEL/TAO

Cartoon of the ENSO Ocean/ Atmosphere system (see text for details).
Image from: <http://www.pmel.noaa.gov/tao/elnino/nino-home.html#>

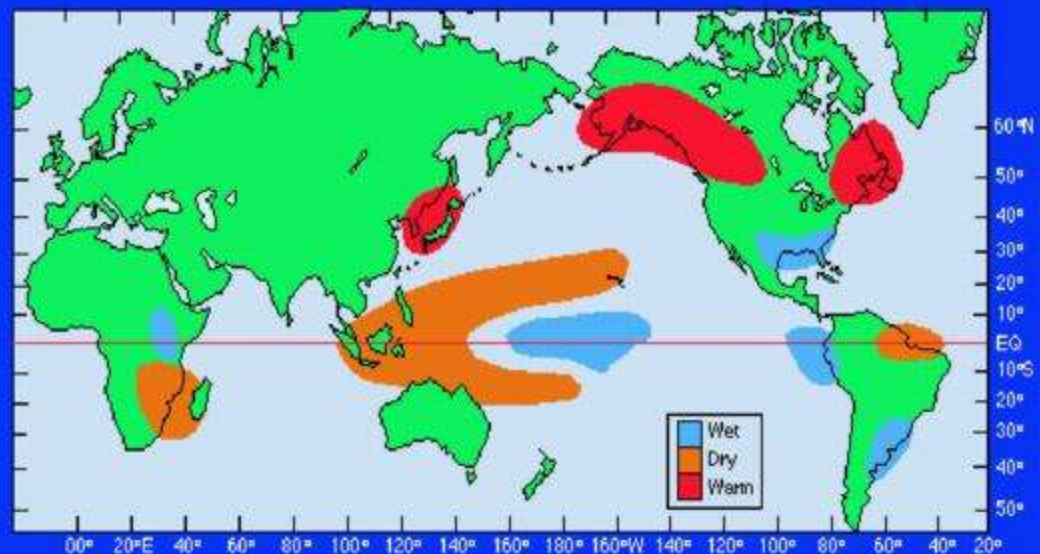
Teleconnections related to El Nino events

<http://www.pmel.noaa.gov/tao/elnino/impacts.html>

Northern Hemisphere Summer



Northern Hemisphere Winter



Other Multi-Year Atmospheric and Oceanic Cycles

- Pacific Decadal Oscillation
 - Approximately every 20 to 30 years sea surface temperatures in the northern/west tropical and eastern tropical Pacific Ocean
- The North Atlantic Oscillation (NAO) and Arctic Oscillation
 - The NAO – irregular “seesaw” of pressure differences between two regional components of the general atmospheric circulation of the Northern Atlantic basin
 - Arctic Oscillation alternates warm and cold phases as in the NAO.



